Figure 1.

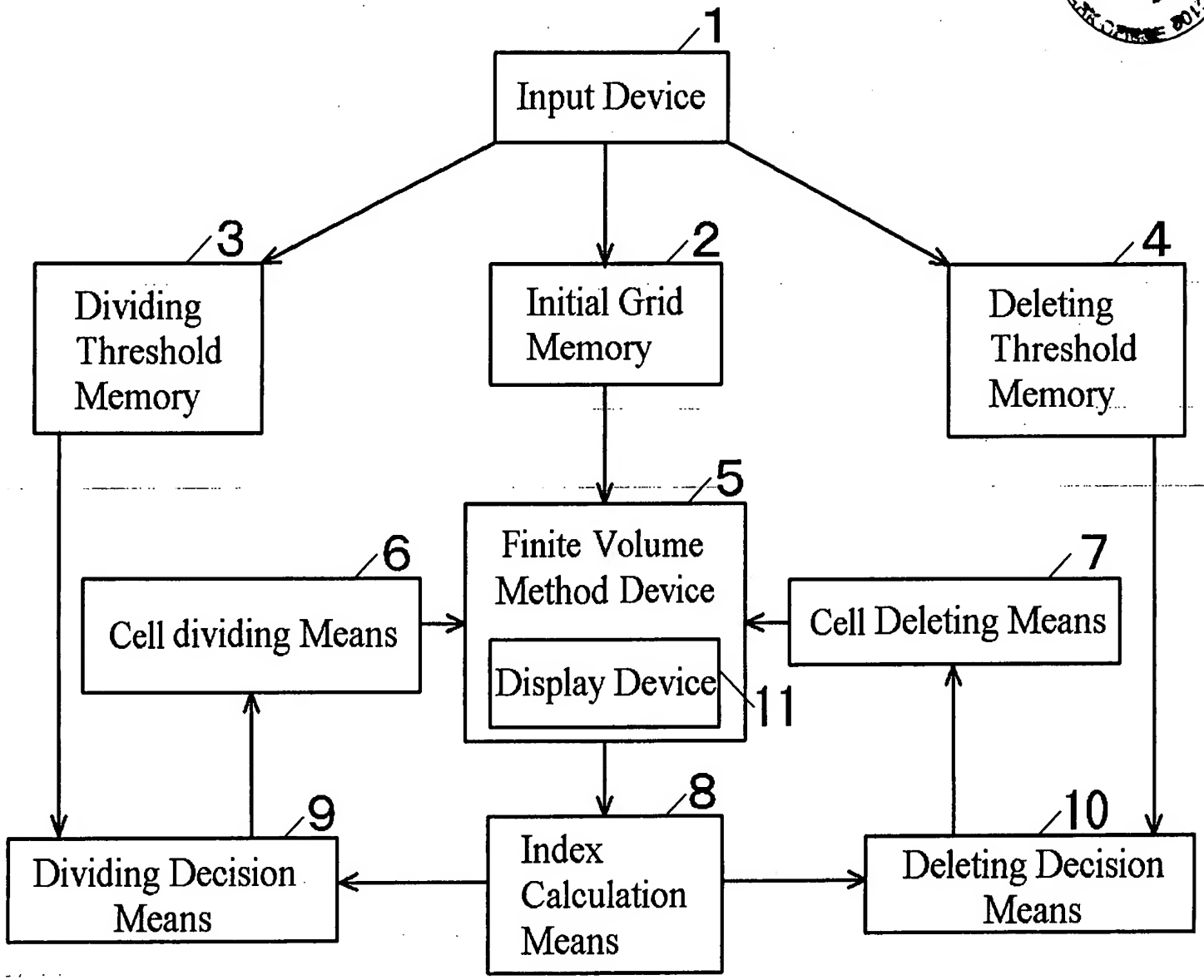


Figure 2.

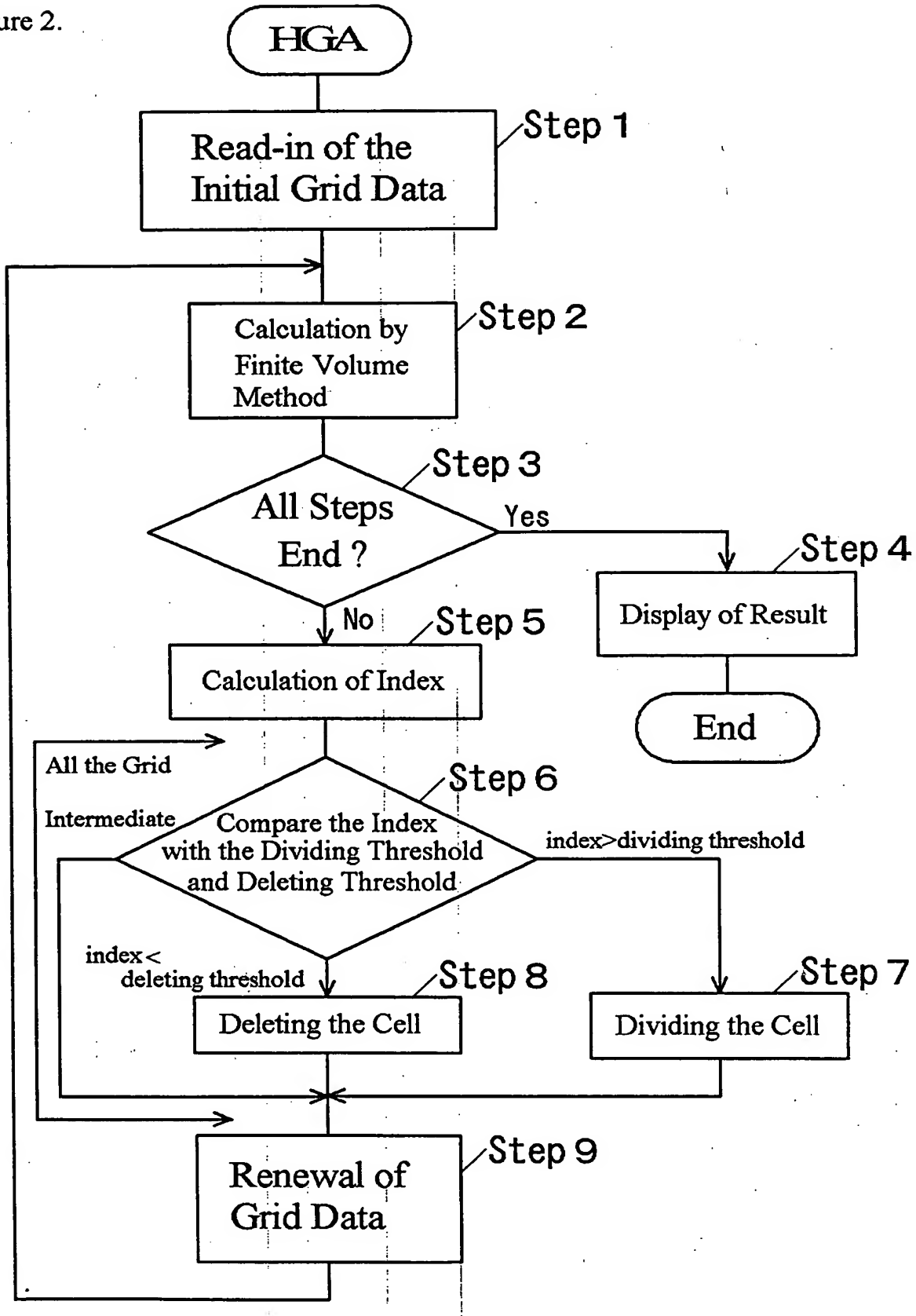
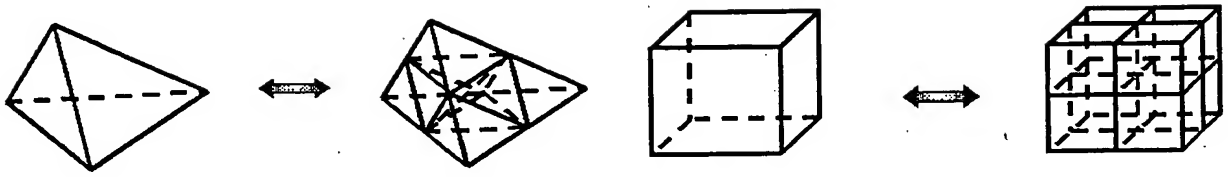
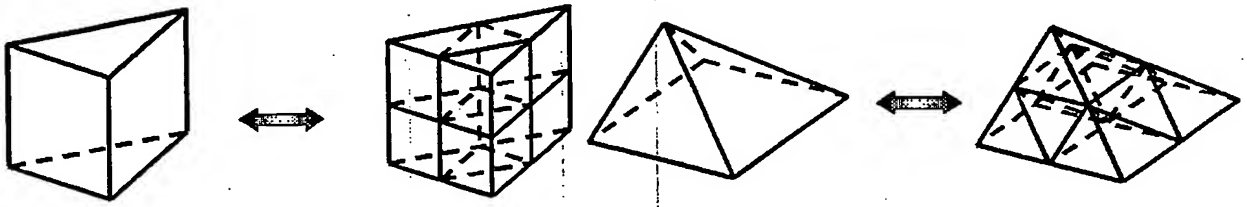

HGA
Read-in of the Initial Grid Data
Step 1
Calculation by Finite Volume Method
Step 2
All Steps End ?
Step 3
Yes
No
Display of Result
Step 4
End
Calculation of Index
Step 5
All the Grid
Intermediate
Compare the Index with the Dividing Threshold and Deleting Threshold
Step 6
index>dividing threshold
index< deleting threshold
Deleting the Cell
Step 8
Dividing the Cell
Step 7
Renewal of Grid Data
Step 9

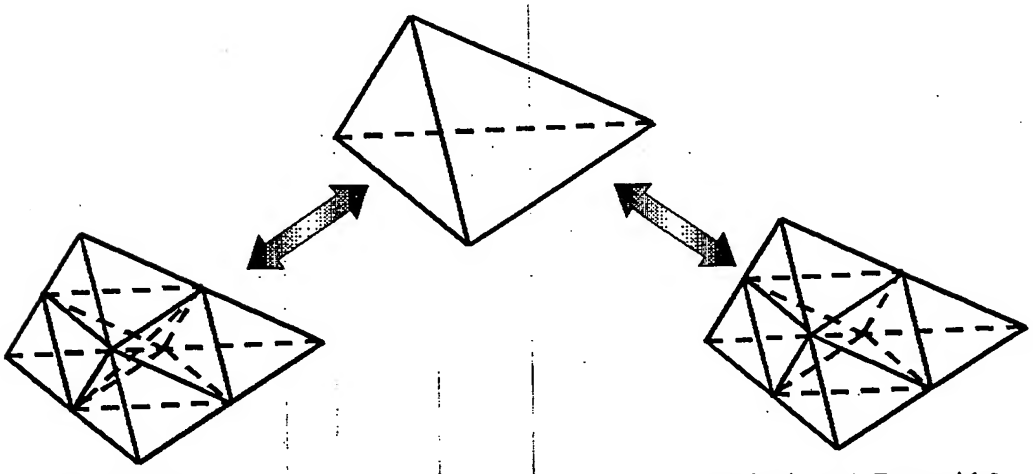
Figure 3.



(a) Tetrahedron:8 (b) Hexahedron:8



(c) Prism:8 (d) Pyramid:6, Tetrahedron:4



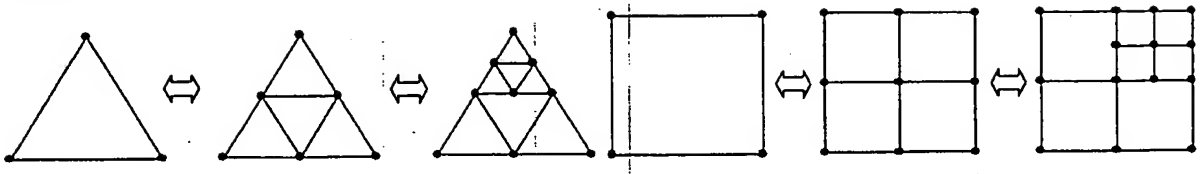
Tetrahedron:8
(Type 1)

Tetrahedron:4, Pyramid:2
(Type 2)

	Level 0	Level 1	Level 2	Level 3	Level 4
Tetrahedron:8 (Type 1)	1	8	64	512	4096
Tetrahedron:4 Pyramid:2 (Type 2)	1	6	44	328	2448

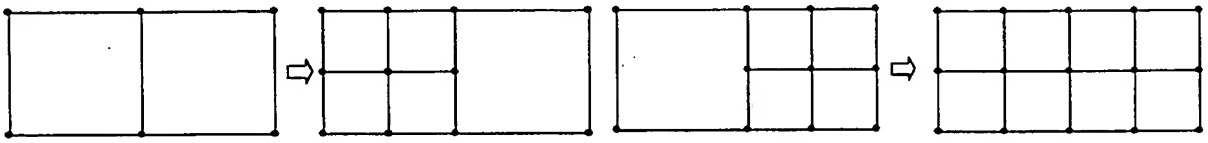
(e)Division by 6 of tetrahdron

Figure 4.



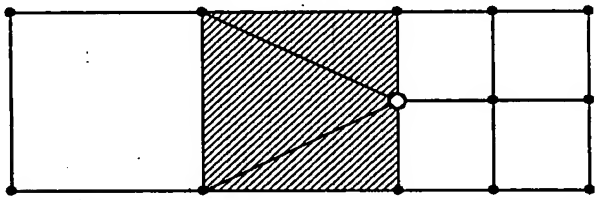
(a) Triangle (b) Quadrilateral

Refining and coarsening of boundary surface of grid

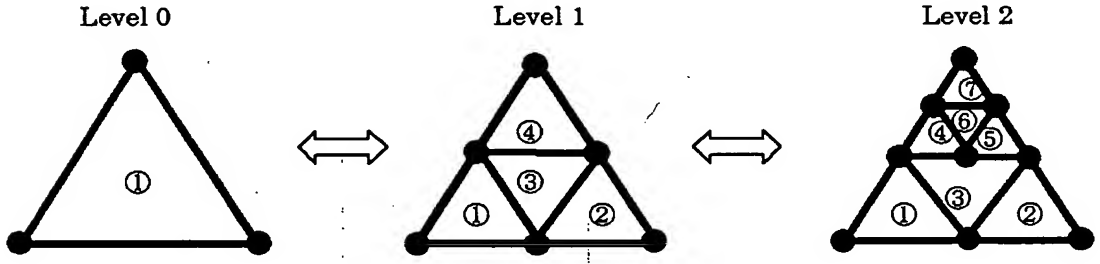


(c) Difference of grid level=0 (d) difference of grid level=1

Differnce of grid level (refining)



(e) Hanging node and Temporary grid (2D, quarilateral grid)



cp[1]->parent[0] = ①
cp[1]->brother[0] = 0

cp[1]->parent[1] = ①
cp[1]->brother[1] = ②
cp[2]->parent[1] = ①
cp[2]-> brother[1] = ③
cp[3]->parent[1] = ①
cp[3]-> brother[1] = ④
cp[4]->parent[1] = ①
cp[4]-> brother[1] = ①

cp[4]->parent[2] = ④
cp[4]->brother[2] = ⑤
cp[5]->parent[2] = ④
cp[5]->brother[2] = ⑥
cp[6]->parent[2] = ④
cp[6]->brother[2] = ⑦
cp[7]->parent[2] = ④
cp[7]->brother[2] = ④

(f) Family Relation

Figure 5.

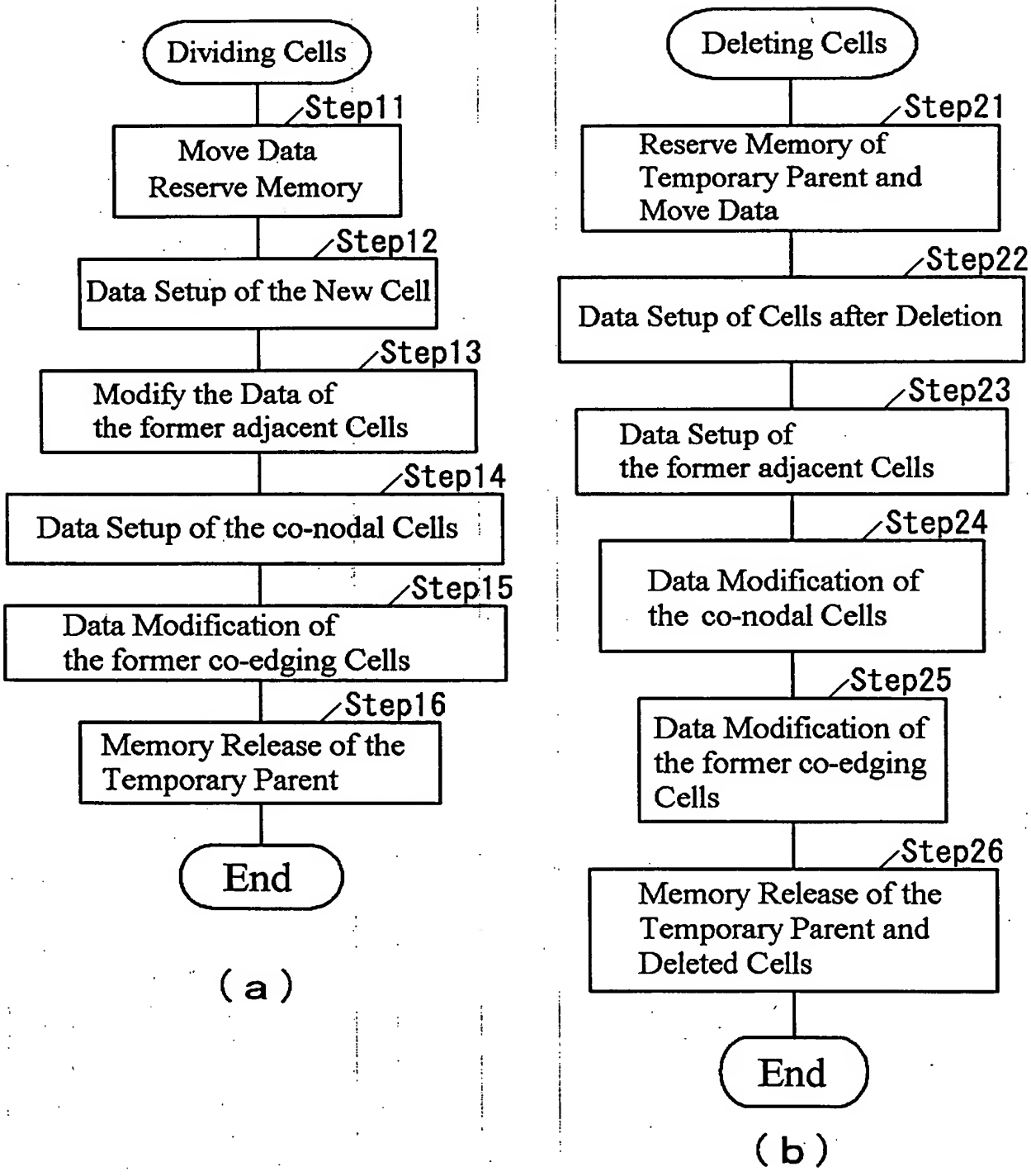
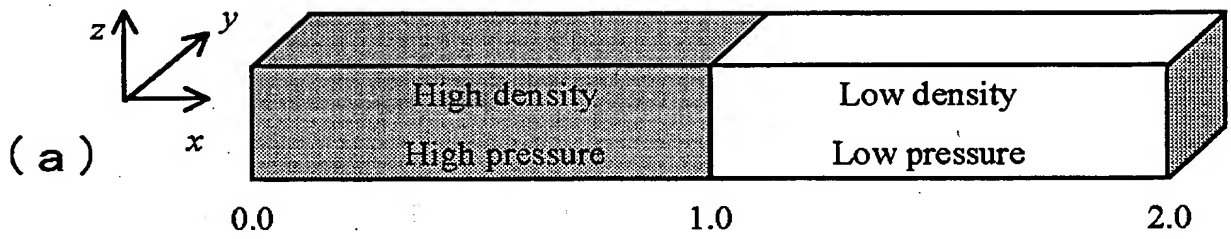
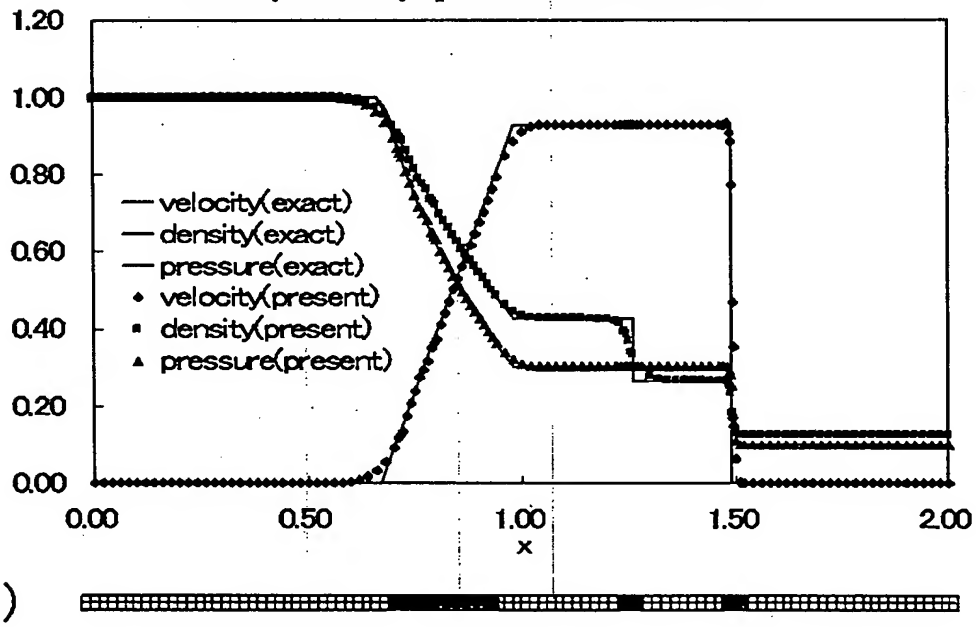

Dividing Cells
Step11
Move Data
Reserve Memory
Step12
Data Setup of the New Cell
Step13
Modify the Data of
the former adjacent Cells
Step14
Data Setup of the co-nodal Cells
Step15
Data Modification of
the former co-edging Cells
Step16
Memory Release of the
Temporary Parent
End
(a)
Deleting Cells
Step21
Reserve Memory of
Temporary Parent and
Move Data
Step22
Data Setup of Cells after Deletion
Step23
Data Setup of
the former adjacent Cells
Step24
Data Modification of
the co-nodal Cells
Step25
Data Modification of
the former co-edging
Cells
Step26
Memory Release of the
Temporary Parent and
Deleted Cells
End
(b)

Figure 6.

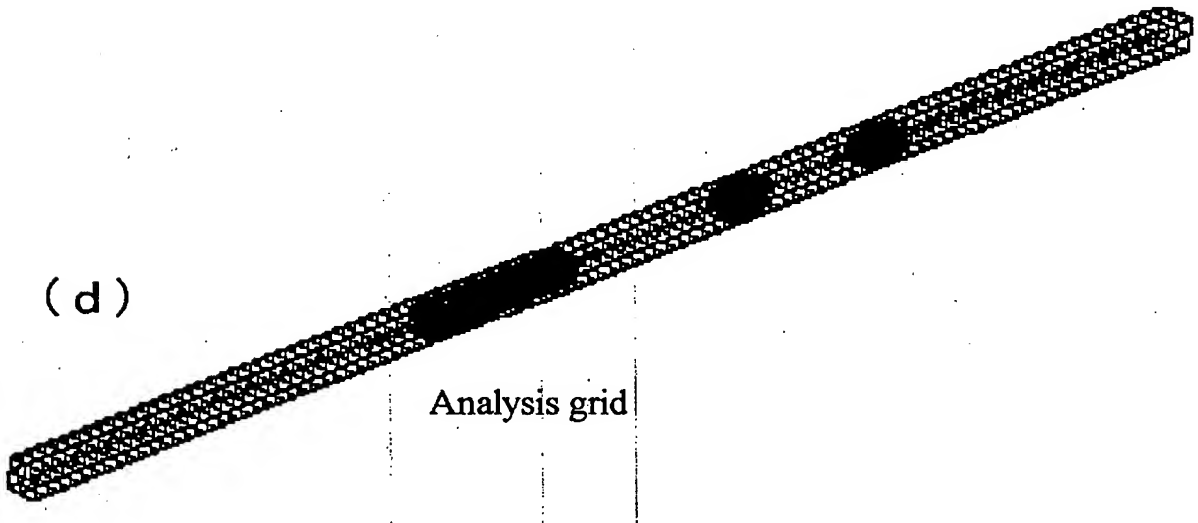


(a) Analysis domain for shock tube problem

(b) Velocity, density, pressure distributions



(c)



(d) Analysis grid

Figure 7.

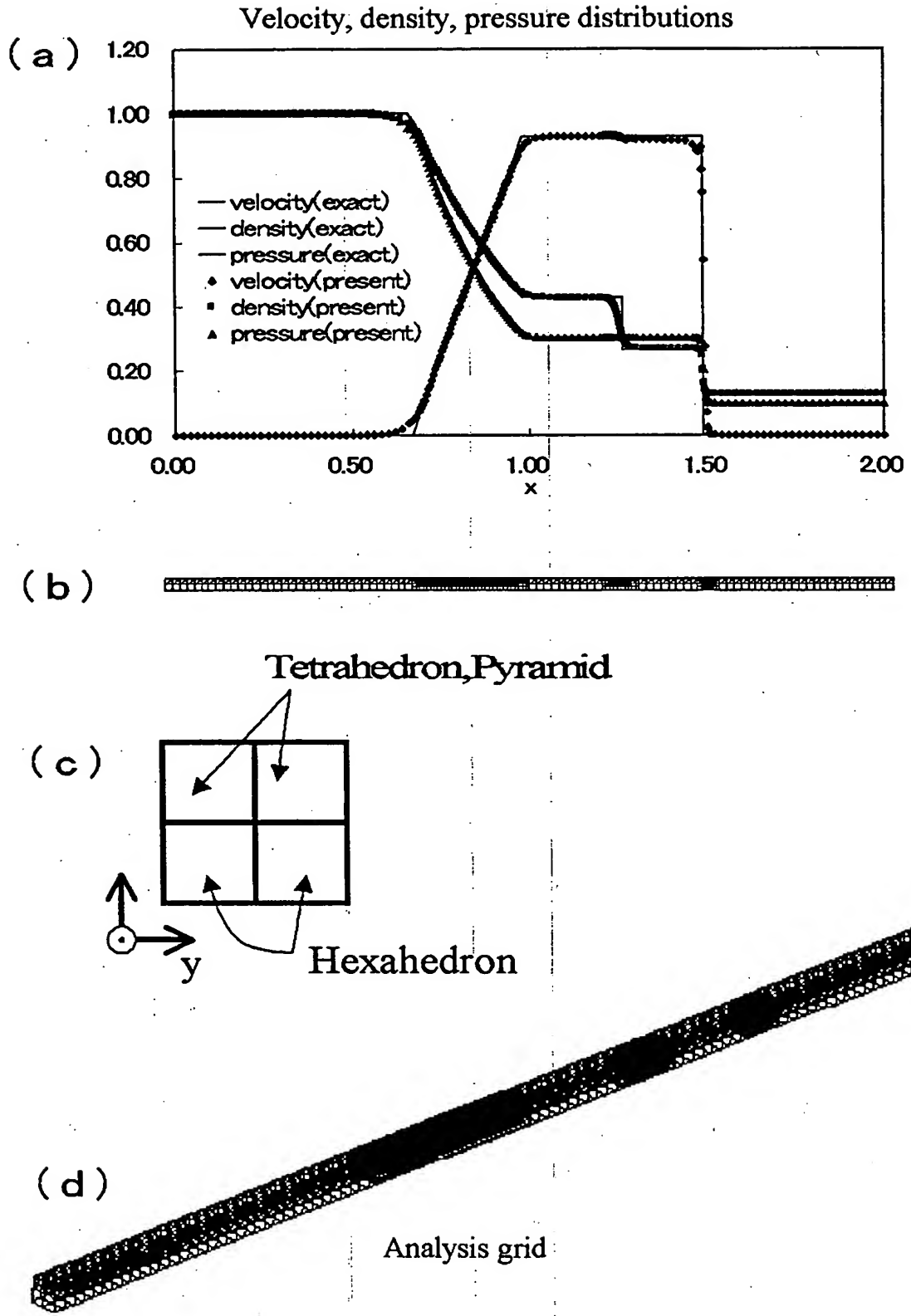
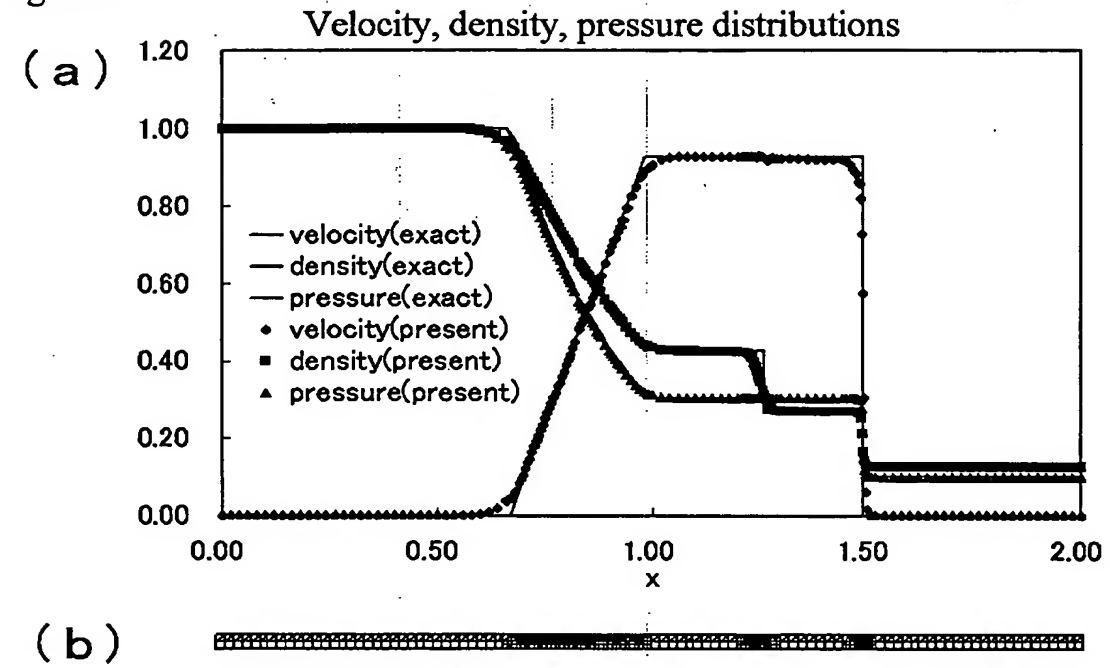
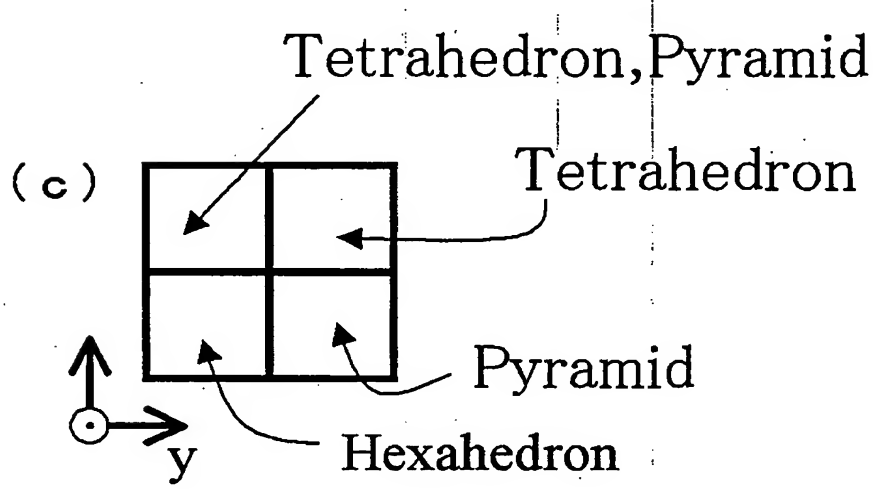

Velocity, density, pressure distributions
(a)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
velocity(exact)
density(exact)
pressure(exact)
velocity(present)
density(present)
pressure(present)
0.00
0.50
1.00
1.50
2.00
x
(b)
Tetrahedron,Pyramid
(c)
y
Hexahedron
(d)
Analysis grid

Figure 8.


Velocity, density, pressure distributions
(a)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
velocity(exact)
density(exact)
pressure(exact)
velocity(present)
density(present)
pressure(present)
0.00
0.50
1.00
1.50
2.00
x
(b)


Tetrahedron,Pyramid
(c)
Tetrahedron
Pyramid
y
Hexahedron

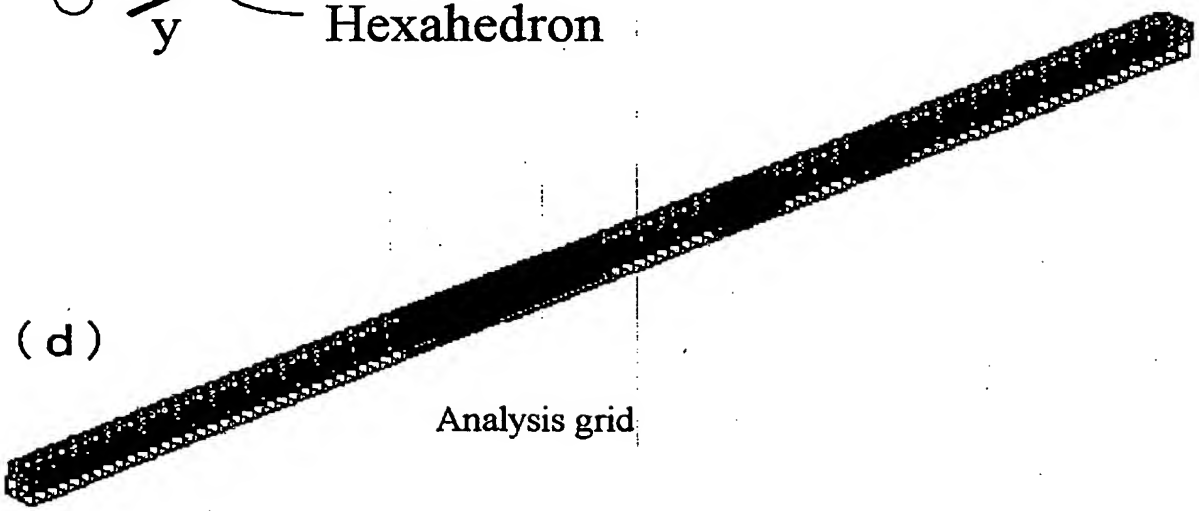

(d)
Analysis grid

Figure 9.

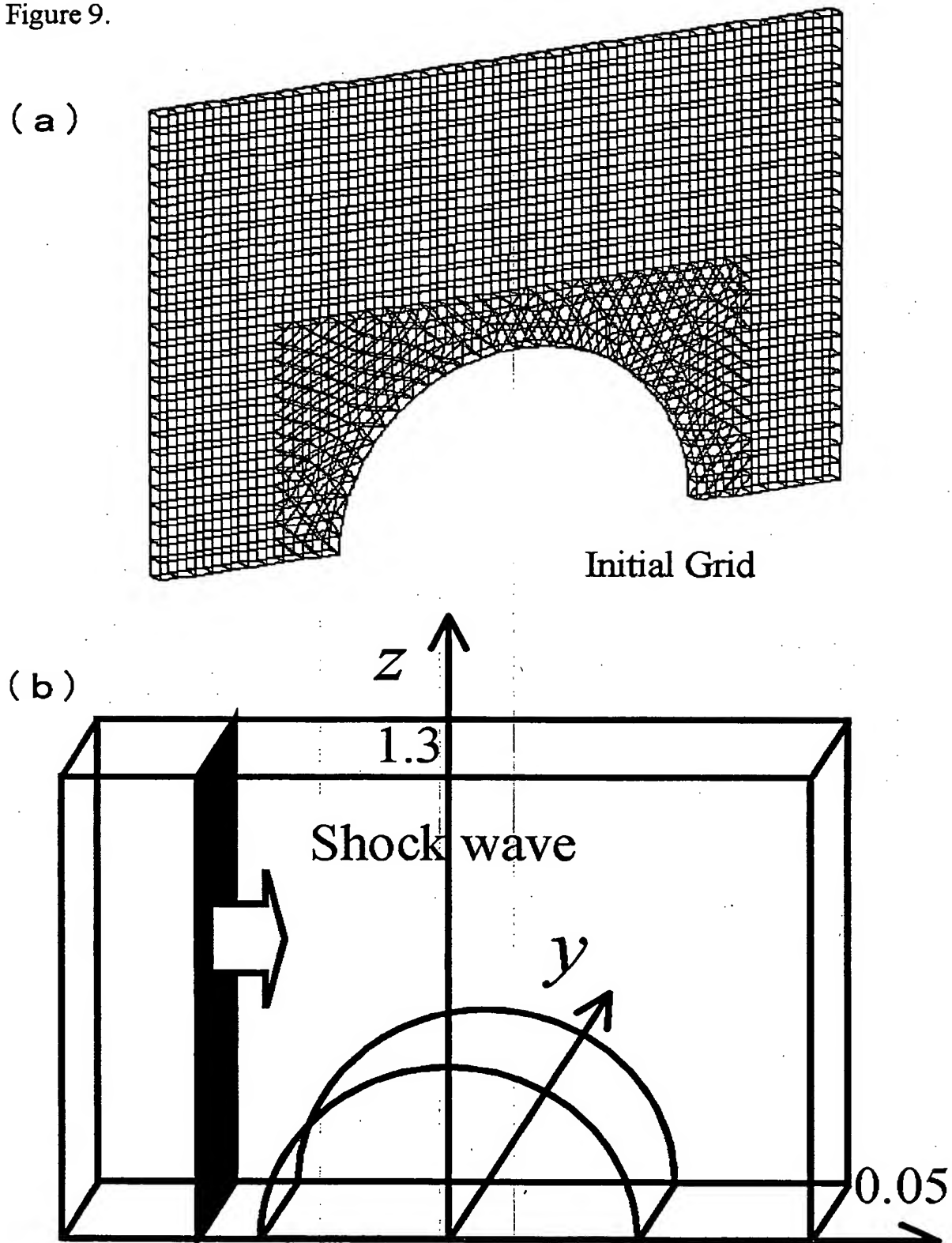
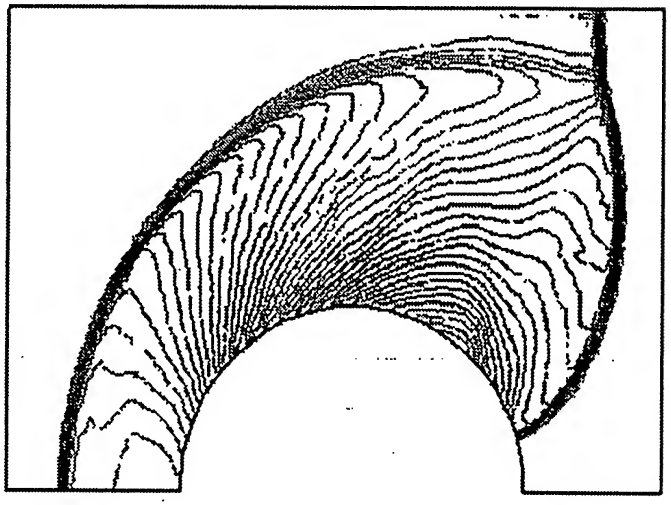
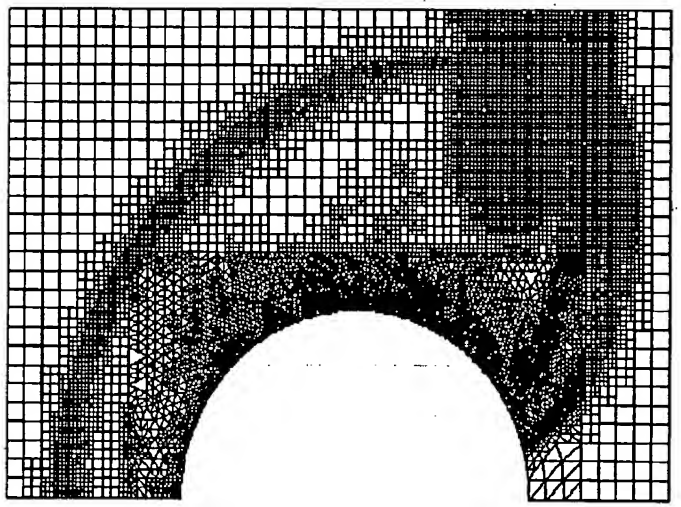

(a)
Initial Grid
(b)
z
1.3
Shock wave
y
0.05
-1.0
-0.5
0.0
0.5
0.9
x
Analysis domain for cylinder flow

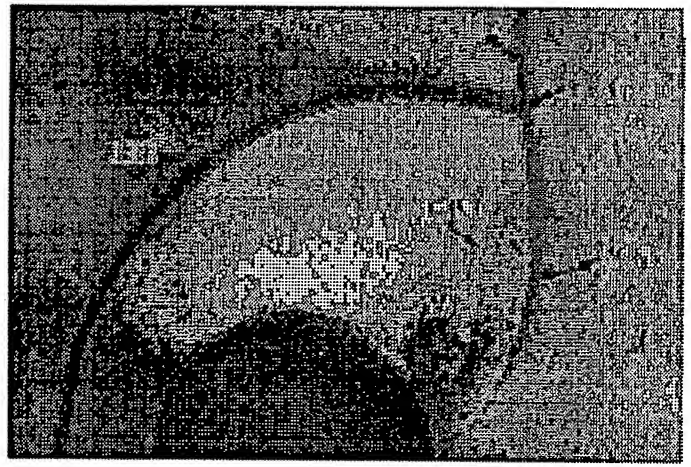
Figure 10.



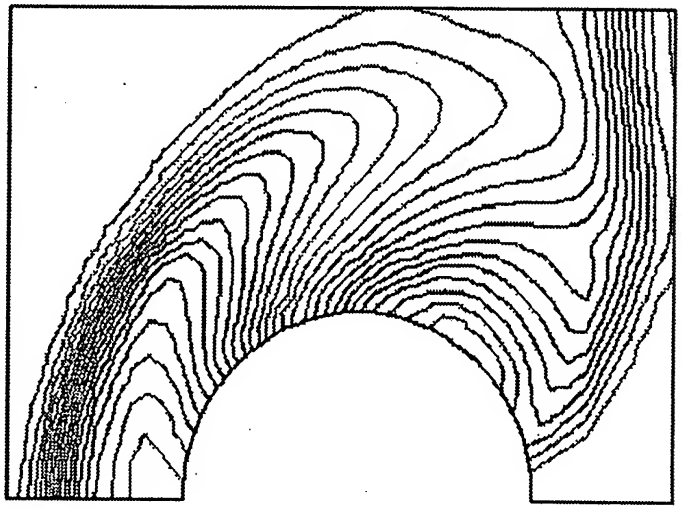
(a) Density contours



(b) Analysis grid (117729 cells)

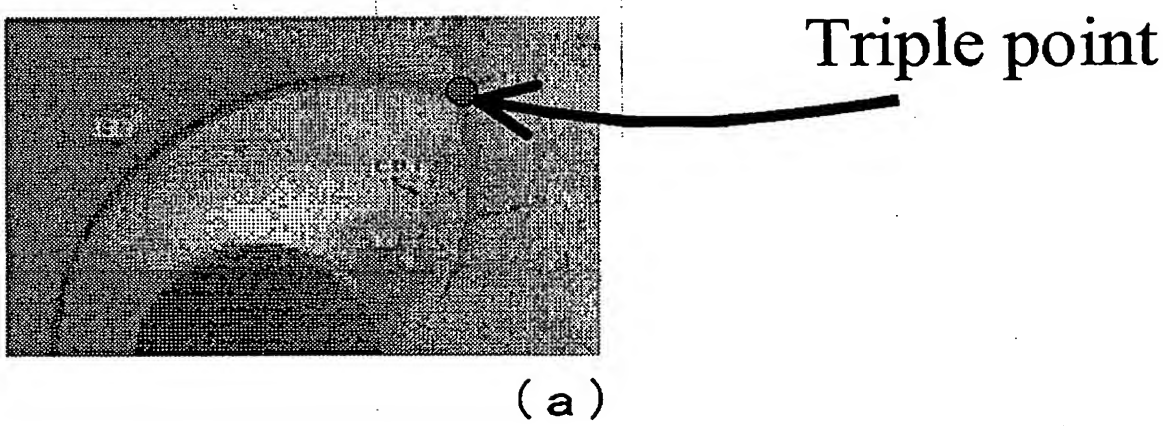


(c) Experiment (Bryson.A.E. and Gross.R.W.F)

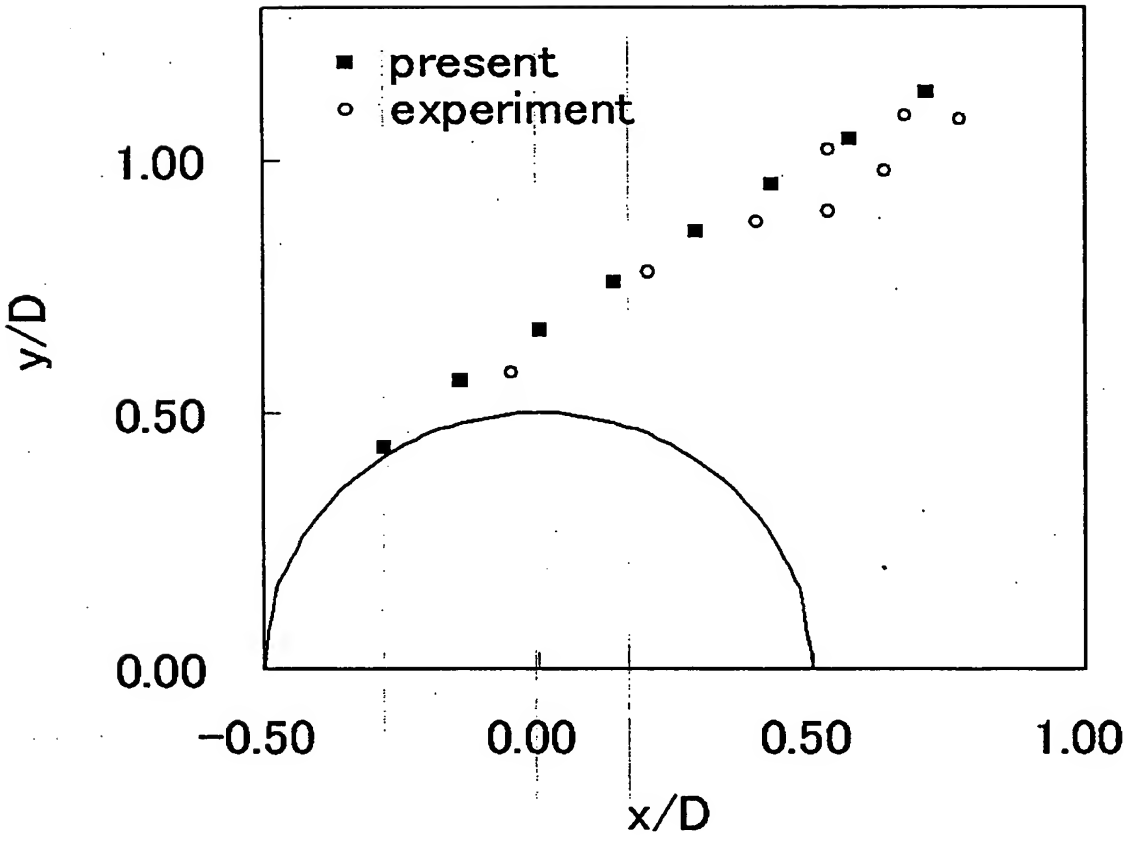


(d) Density contours (without HGA)

Figure 11.

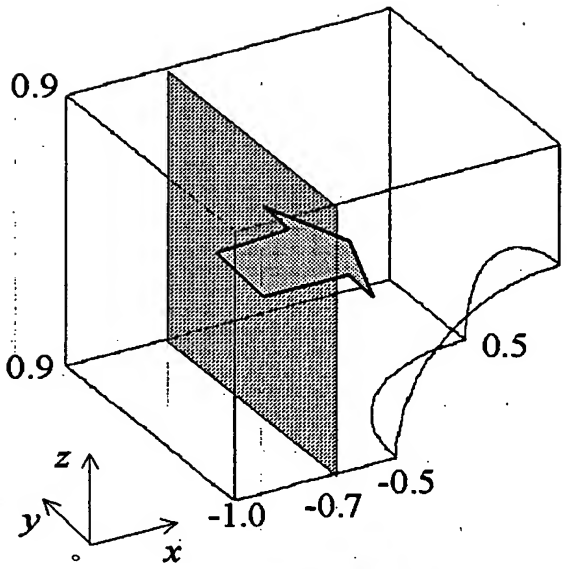


(a)



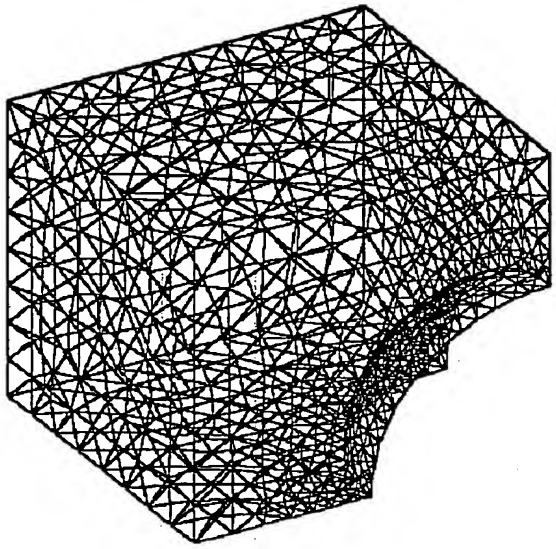
(b) Trajectories of the Mach shock triple point for cylinder flow

Figure 12.



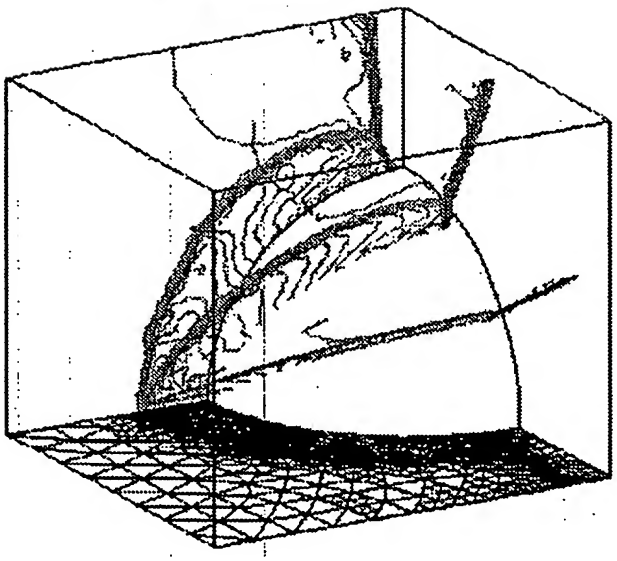
(a)

Analysis domain for sphere flow



(b)

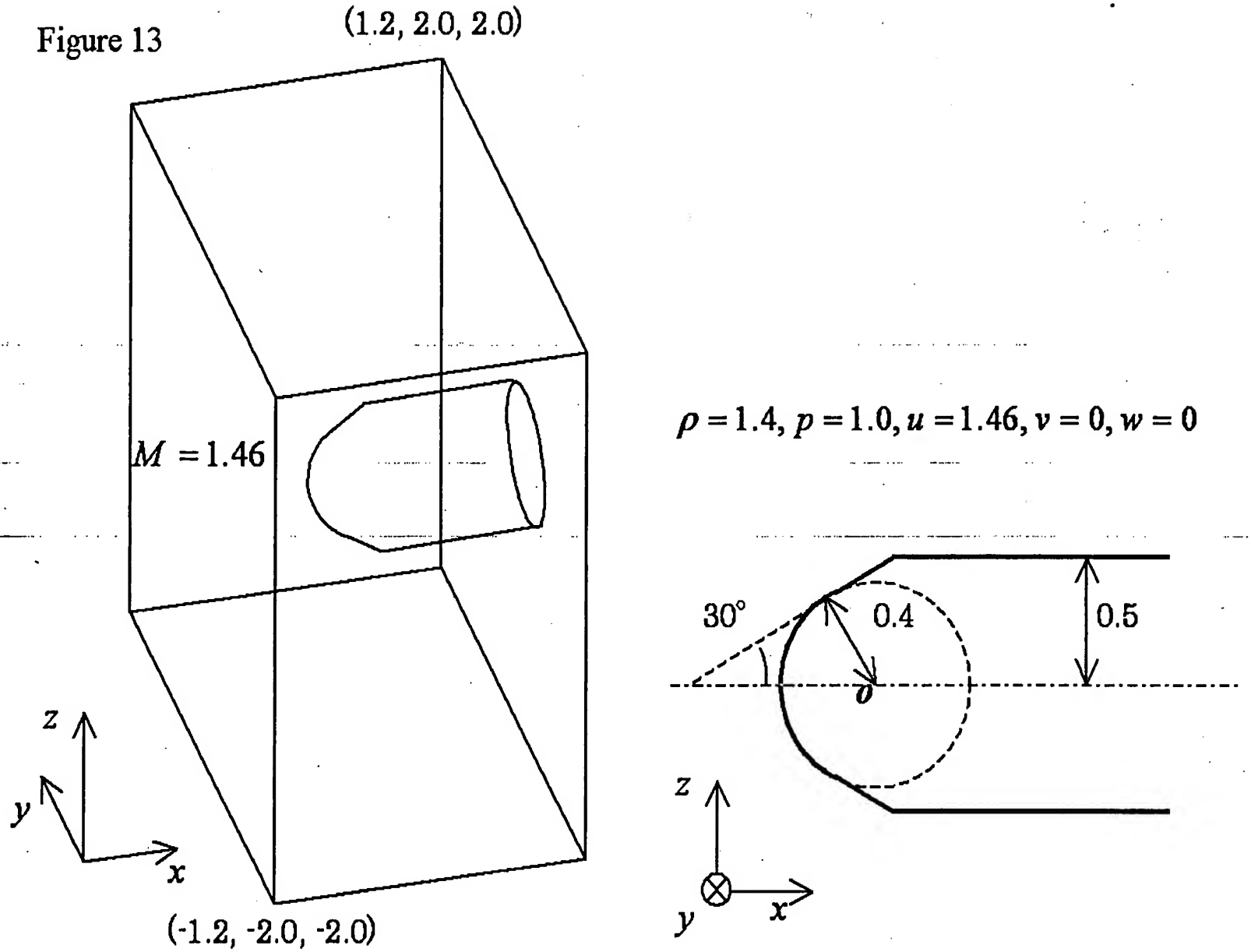
Initial grid



(c)

Density contours

Figure 13

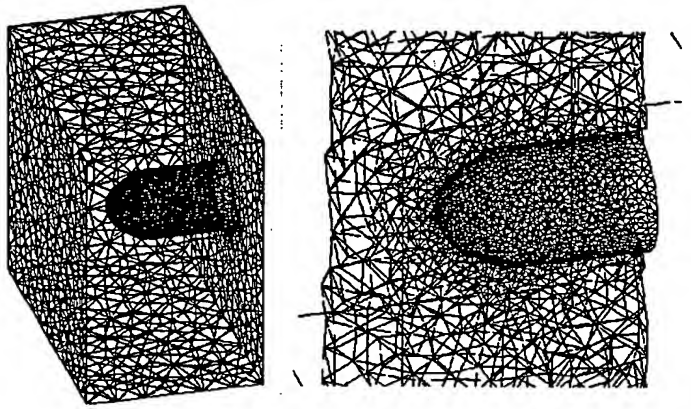


Analysis domain for Spherically blunted cone-cylinder flow

Figure 14

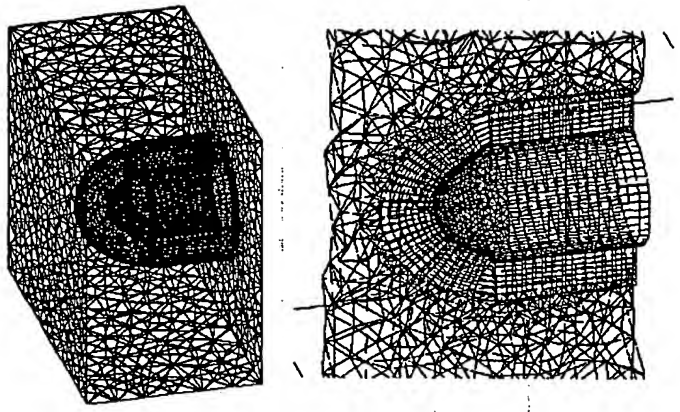
Table 1 : Analysis conditions for Spherically blunted cone-cylinder flow

	Case1	Case2
Initial grid	Tetrahedron	Hybrid
Adaptive type of Tetrahedral	Type1	Type2
Mach number	1.46	
CFL	0.5	



Tetrahedral grid
38673 cells
7687 nodes

(a) Tetrahedral grid

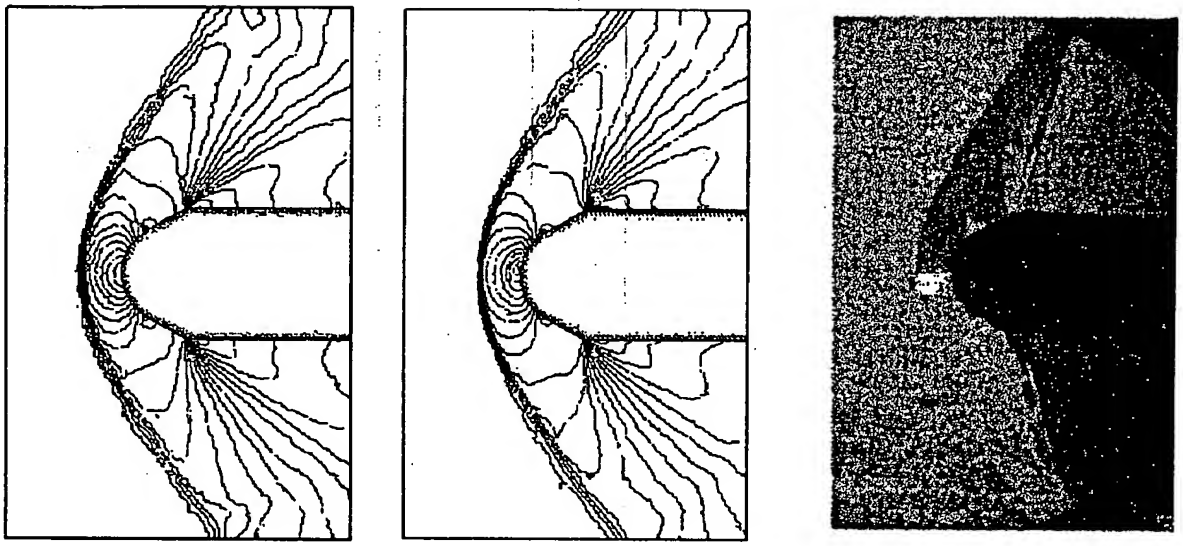


Hybrid grid
49839 cells
Tetrahedron: 35239
Pyramid: 616
Prism: 9056
Hexahedron: 4928
16741 nodes

(b) Hybrid grid

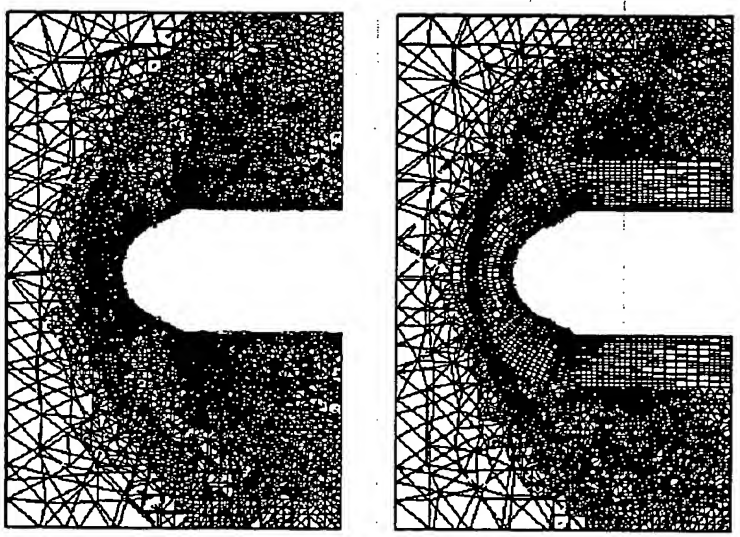
Initial grids for Spherically blunted cone-cylinder flow

Figure 15



Case 1 (Tetrahedron)　　Case 2 (Hybrid)　　Experiment

(a) Density contours



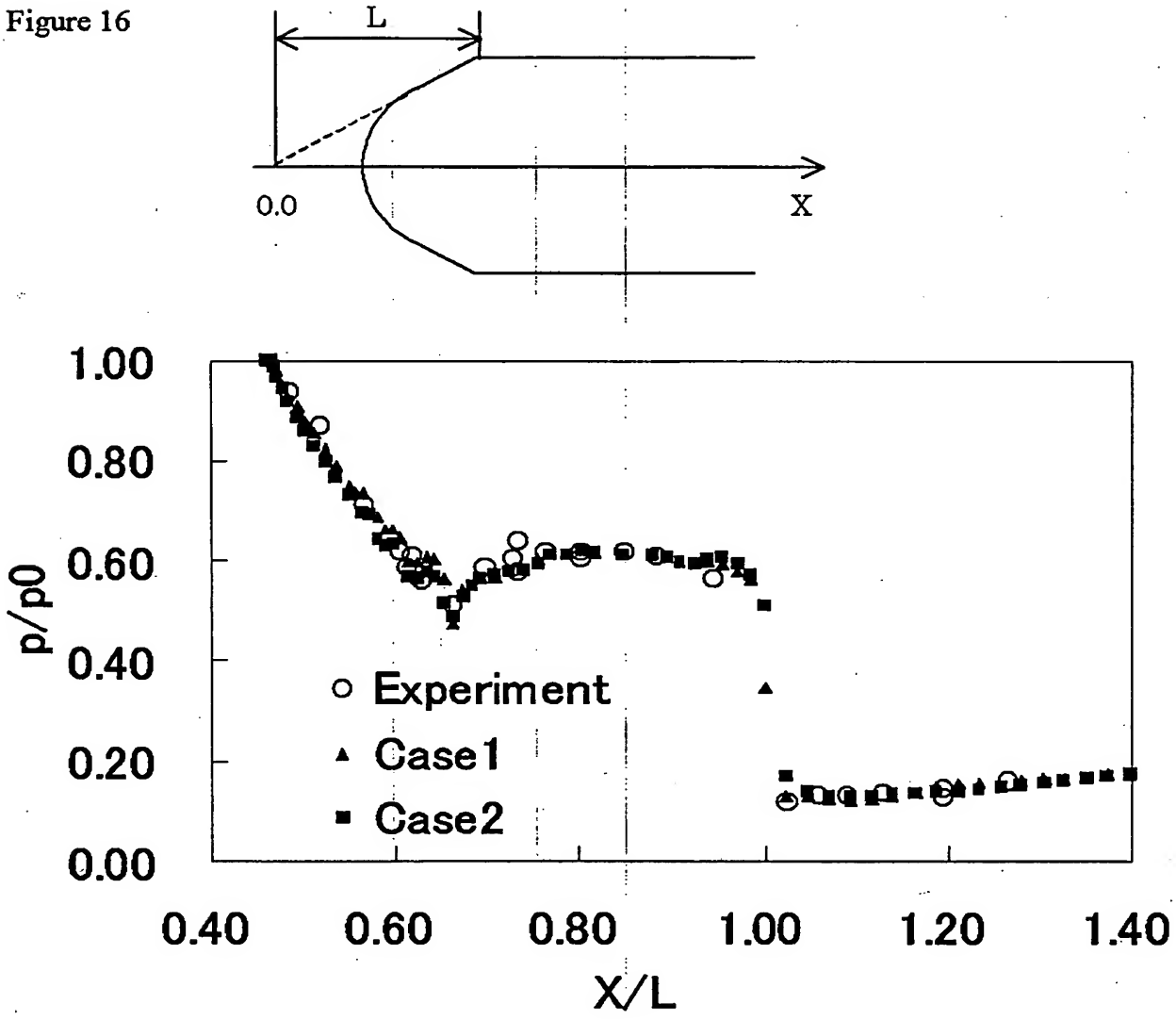
Case 1 (Tetrahedron　　Case 2 (Hybrid)

Case1
1130540 cells, 264140 nodes
Case2
911419 cells, 433201 nodes
Tetrahedron: 375752
Pyramid: 294820
Prism: 178932
Hexahedron: 61915

(b) Analysis grid

Density contours and analysis grid ($y = 0.0$)

Figure 16



Pressure distributions on the spherically blunted cone-cylinder

(Comparison between the present and experiment)